




Information Circular 7
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THE GROUND-WATER PROGRAM FOR PENNSYLVANIA

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TOPOGRAPHIC AND GEOLOGIC SURVEY
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Information Circular 7

THE GROUND-WATER PROGRAM FOR PENNSYLVANIA

Prepared by the United States Geological Survey,
Water Resources Division, in cooperation with
the Pennsylvania Geological Survey

PENNSYLVANIA GEOLOGICAL SURVEY
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THE GROUND-WATER PROGRAM FOR PENNSYLVANIA

PURPOSE OF THE PROGRAM

The objectives of the ground-water program in Pennsylvania are to determine the availability and quality of the ground-water resources of the Commonwealth in order to satisfy the ever-increasing demand that accompanies changing industrial and agricultural uses of water and the expansion of our population centers. There are limits within which we can satisfy the growing demands cited above. We have to recognize and define what those limits are, so that necessary technical and administrative steps can be taken to assure adequate water supplies in the right place at the right time and to wisely manage the presently available water resources.

These objectives can be accomplished only by systematic, detailed investigations of the geologic and hydrologic conditions under which ground water occurs in Pennsylvania, and of the effects on the natural system of certain human activities such as withdrawing water from wells, underground disposal of wastes, and diversion or pollution of natural recharge. These investigations must include the following: geologic studies to determine the location, extent, thickness, and anomalous characteristics of the aquifers (water-bearing formations); hydrologic and geophysical studies to determine the hydraulic properties of the aquifers, the sources and quantities of recharge to the aquifer, the direction and rate of movement of the ground water, and areas of discharge and rates of discharge from the aquifer. Studies must be made to determine the significant chemical and physical characteristics of the ground water, in order to relate the quality of water to the aquifer in which it occurs, and to determine the effects of human activities on the quality of water. Because the water-bearing strata are buried beneath the land surface, most pertinent data must be obtained by indirect methods such as electric logging and related borehole geophysical techniques, microscopic examination of drill cuttings, and pumping tests.

HISTORY OF THE PROGRAM, 1925-75

The major part of the continuing program of ground-water studies in Pennsylvania has been supported by cooperation between the Commonwealth and the Federal Government.

Ground-water investigations began in Pennsylvania in 1925 under a cooperative agreement between the Pennsylvania Geologic Survey and the Ground Water Branch of the United States Geological Survey. The agreement continued to 1943, by which time all parts of the State had been covered by reconnaissance studies which were described in six area reports and one statewide report published by the Pennsylvania Geological Survey. In 1930, a statewide network of observation wells was established and designed to determine the long-term trends of ground-water levels in rural areas largely unaffected by local withdrawals from wells. This study has been kept current, and in recent years it has been greatly expanded to include nearly every county in the State. The locations of these wells are shown in Figure 1.

The six area reports, Water Resource Reports 1 through 6, describe the geological and ground-water conditions for each county and have a tabular listing of several well records per county. Despite their early printing, they are still widely used, and provide the reader with a quick summary of ground-water conditions of each county (see Figure 2).

Since 1943, the cooperative program between the Pennsylvania Geological Survey and the United States Geological Survey has expanded steadily with the recognition of the importance of ground-water supplies to Pennsylvania. This newly intensified cooperative program marked the beginning of a series of detailed local ground-water studies. Four major ground-water reports were completed during the period 1945 to 1955. These reports were systematic detailed studies of the hydrology of the important ground-water aquifers that occur in Pennsylvania.

As the science of hydrology advanced during the latter part of the 1950's and through the 1960's, new techniques and tools evolved. Our geologists and engineers were able to apply these new methods of testing and studying Pennsylvania's ground-water aquifers with a net result that the Pennsylvania Geological Survey was able to publish highly detailed and accurate ground-water reports during this period. The Survey accomplished studies of ground water in each of the widely different physiographic and geologic provinces of the State. The eighteen major detailed ground-water reports finished between 1960 and 1970 were concerned with the occurrence and movement of ground water in each of these different geologic regions. Every region and each rock formation within a region has special characteristics that must be defined and that ultimately provide the clues to the quantity and quality of ground water available. The principal objectives in these reports are the determination of total well yield, well depth, depth of water-bearing zones, depth of weathering, and the chemical quality of the water as each of these factors relates to geologic structure, rock type, and topographic position of the well.

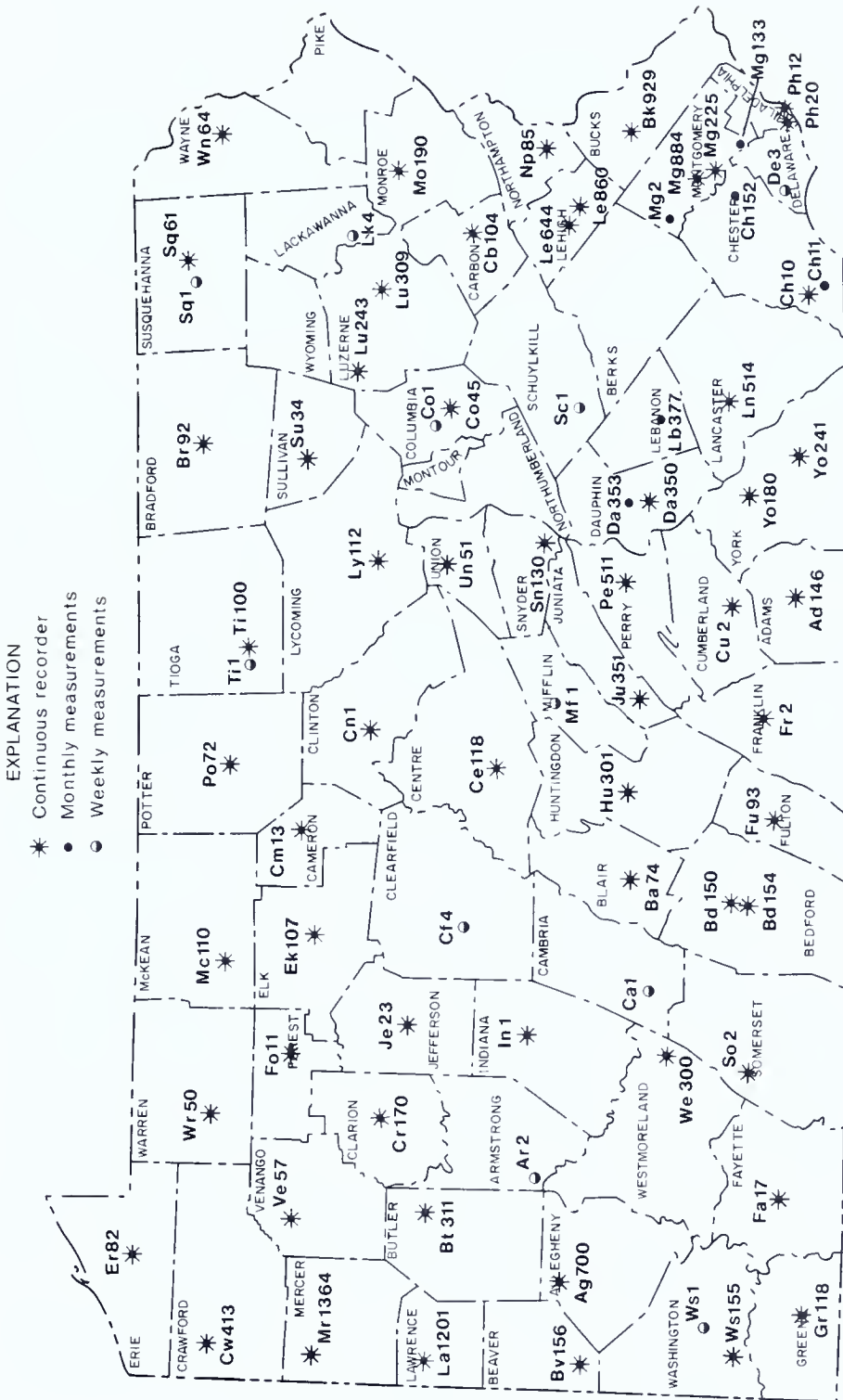


Figure 1. Observation wells in Pennsylvania, January 1975.

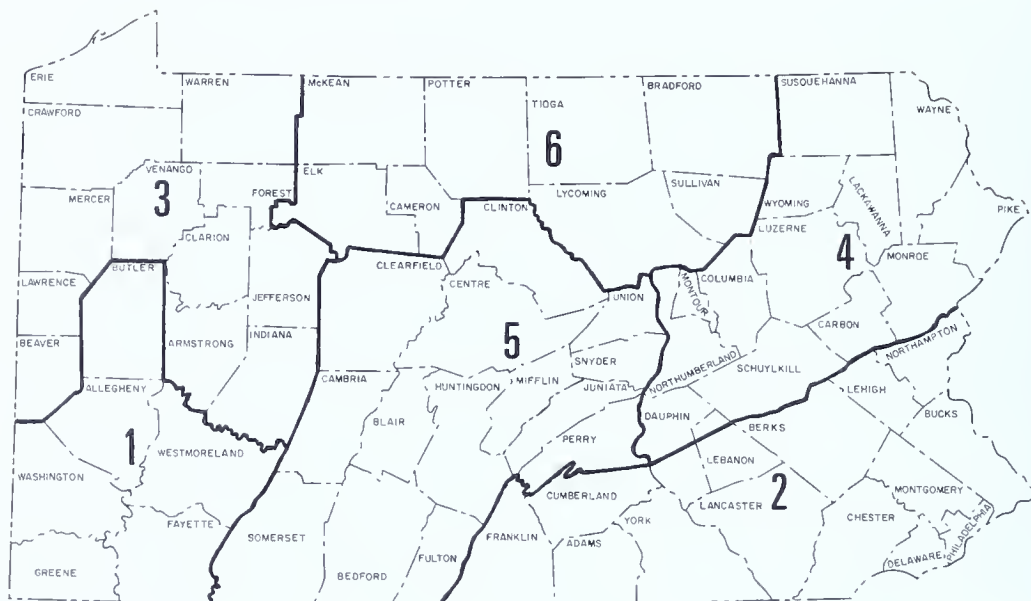


Figure 2. Index of regional reports.

Following is a bibliography of the reports prepared for detailed studies under the Pennsylvania ground-water program. The areas covered by the individual project studies are shown in Figure 3.

- W 1 *Ground water in southwestern Pennsylvania*, by A. M. Piper, 1933, 41 p., 40 figs.
- W 2 *Ground water in southeastern Pennsylvania*, by G. M. Hall, 1934; 2nd printing, 1967, 255 p., 7 figs., 7 pls.
- W 3 *Ground water in northwestern Pennsylvania*, by R. M. Leggette, 1936; 2nd printing, 1957, 215 p., 15 figs., 9 pls.
- W 4 *Ground water in northeastern Pennsylvania*, by S. W. Lohman, 1937; 2nd printing, 1957, 300 p., 18 figs., 7 pls.
- W 5 *Ground water in south-central Pennsylvania*, by S. W. Lohman, 1938; 3rd printing, 1974, 315 p., 11 figs., 19 pls.
- W 6 *Ground water in north-central Pennsylvania*, by S. W. Lohman, 1939; 2nd printing, 1967, 220 p., 13 figs., 11 pls.
- W 7 *Ground-water resources of Pennsylvania*, by S. W. Lohman, 1941, 32 p., 11 figs., 1 pl.
- W 8 *Ground-water resources of the valley-fill deposits of Allegheny County, Pennsylvania*, by J. H. Adamson and others, 1949, 181 p., 9 figs., 3 tables, 5 pls.
- W 9 *Ground-water resources of Beaver County, Pennsylvania*, by D. W. VanTuyl and N. H. Klein, 1951, 84 p., 11 figs., 10 tables, 1 pl.
- W 10 *Ground water for air conditioning at Pittsburgh, Pennsylvania*, by D. W. VanTuyl, 1951, 34 p., 9 figs., 9 tables.
- W 11 *Ground-water resources of Bucks County, Pennsylvania*, by D. W. Greenman, 1955, 67 p., 1 fig., 6 tables, 2 pls.
- W 12 *Borehole geophysical methods of analyzing the specific capacity of aquifers in a multiaquifer well*, by G. D. Bennett and E. P. Patten, 1960, 27 p., 8 figs., 2 tables.

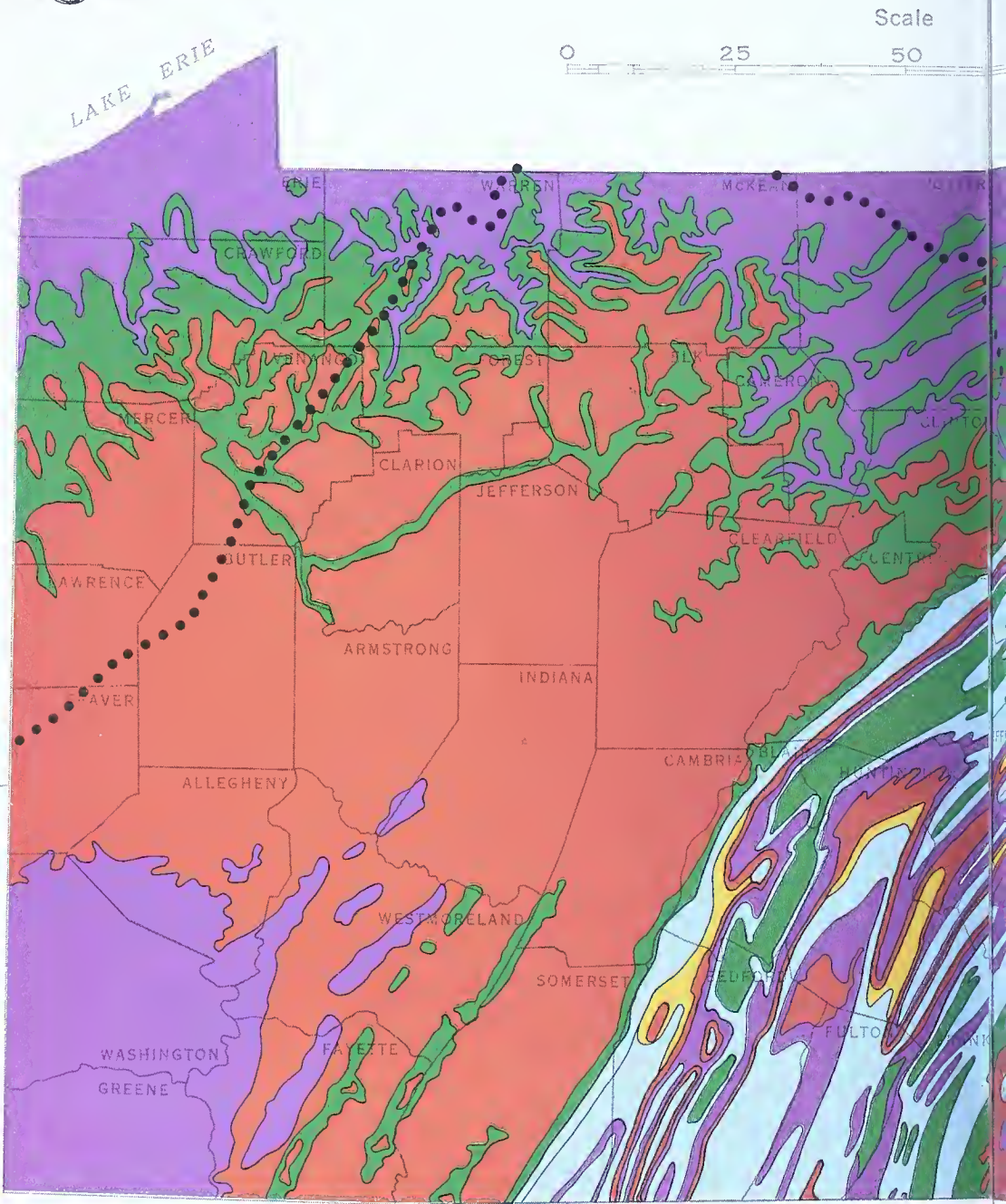


Figure 3. Areas covered by detailed ground-water reports, current and future projects.

- W 13 *Ground-water resources of the Coastal Plain area of southeastern Pennsylvania*, by D. W. Greenman and others, 1961, 375 p., 27 figs., 15 tables, 22 pls.
- W 14 *Geology and hydrology of the Stockton Formation in southeastern Pennsylvania*, by D. R. Rima, Harold Meisler, and Stanley Longwill, 1962, 11 p., 8 tables, 4 pls.
- W 15 *Geology and hydrology of the Neshannock quadrangle, Mercer and Lawrence Counties, Pennsylvania*, by L. D. Carswell and G. D. Bennett, 1963, 98 p., 8 figs., 3 tables, 4 pls.
- W 16 *Geology and hydrology of the Mercer quadrangle, Mercer, Lawrence, and Butler Counties, Pennsylvania*, by C. W. Poth, 1963, 149 p., 24 figs., 6 tables, 5 pls.
- W 17 *Methods of flow measurement in well bores*, by E. P. Patten, Jr. and G. D. Bennett, 1963; 2nd printing, 1974, 28 p., 13 figs., 1 table; also available as U. S. Geological Survey Water-Supply Paper 1544c.
- W 18 *Hydrogeology of the carbonate rocks of the Lebanon Valley, Pennsylvania*, by Harold Meisler, 1963, 81 p., 18 figs., 3 tables, 3 pls.
- W 19 *Application of electrical and radioactive well logging to ground-water hydrology*, by E. P. Patten, Jr. and G. D. Bennett, 1963, 60 p., 11 figs.
- W 20 *The ground-water observation well program in Pennsylvania*, by C. W. Poth, 1963; 2nd edition, 1972, 17 p., 8 figs.
- W 21 *Hydrology of the New Oxford Formation in Adams and York Counties, Pennsylvania*, by P. R. Wood and H. E. Johnston, 1964, 66 p., 10 figs., 8 tables, 1 pl.
- W 22 *Ground-water resources of the Brunswick Formation in Montgomery and Berks Counties, Pennsylvania*, by S. M. Longwill and C. R. Wood, 1965, 59 p., 13 figs., 7 tables, 1 pl.
- W 23 *Hydrology of the New Oxford Formation in Lancaster County, Pennsylvania*, by H. E. Johnston, 1966, 80 p., 11 figs., 6 tables, 1 pl.
- W 24 *Geology and hydrology of the Martinsburg Formation in Dauphin County, Pennsylvania*, by L. D. Carswell, J. R. Hollowell, and L. B. Platt, 1968, 54 p., 17 figs., 3 tables, 1 pl.
- W 25 *Hydrology of the metamorphic and igneous rocks of central Chester County, Pennsylvania*, by C. W. Poth, 1968; 2nd printing, 1973, 84 p., 29 figs., 6 tables, 3 pls.
- W 26 *Hydrogeology of the carbonate rocks of the Lancaster 15-minute quadrangle, southeastern Pennsylvania*, by H. E. Meisler and A. E. Becher, 1971; 2nd printing, 1973, 149 p., 25 figs., 11 tables, 2 pls.
- W 27 *Ground-water resources of the Loysville and Mifflintown quadrangles in south-central Pennsylvania*, by H. E. Johnston, 1970; 2nd printing, 1973, 96 p., 12 figs., 14 tables, 2 pl.
- W 28 *Hydrology of the Pleistocene sediments in the Wyoming Valley, Luzerne County, Pennsylvania*, by J. R. Hollowell, 1971; 2nd printing, 1973, 77 p., 16 figs., 7 tables, 4 pls.
- W 30 *Hydrology of the Martinsburg Formation in Lehigh and Northampton Counties, Pennsylvania*, by C. W. Poth, 1972, 5 figs., 7 tables, 1 pl.
- W 31 *Water resources of Lehigh County, Pennsylvania*, by C. R. Wood and others, 1972, 263 p., 47 figs., 49 tables, 5 pls.
- W 33 *Water resources of northern Mercer County, Pennsylvania*, by G. R. Schiner and G. E. Kimmel, in press.
- W 41 *Ground-water resources of Lackawanna County, Pennsylvania*, by J. R. Hollowell and H. E. Koester, in press.



WATER YIELDING OF ROCKS OF PENNSYLVANIA



Median yield is the yield in the middle of the range of yields of a rock formation. Each of the five colors on the map includes several formations, each with its own median yield figure. The range given for each color is from the formation with the highest median yield.

ESTIMATED MEDIAN YIELD



..... Southern

COMMONWEALTH OF PENNSYLVANIA
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75 100 miles



Yields of wells in glacial and stream deposits of sand and gravel range from 20 to 2000 gpm.

PR 146 *Ground-water resources of the Lansdale area, Pennsylvania*, by D. R. Rima, 1955, 24 p., 4 figs., 1 table, 7 pls.

In addition to these detailed reports, summary reports of the ground-water resources of nine counties have been compiled. They are listed below.

W 29 *Ground-water resources of Montgomery County, Pennsylvania*, by T. G. Newport, 1971; 2nd printing, 1973, 83 p., 14 figs., 7 tables, 2 pls.

W 32 *Summary ground-water resources of Clarion County, Pennsylvania*, by T. G. Newport, 1973, 42 p., 6 figs., 7 tables, 1 pl.

W 34 *Summary ground-water resources of Armstrong County*, by C. W. Poth, 1973, 38 p., 6 figs., 7 tables, 1 pl.

W 35 *Summary ground-water resources of Allegheny County, Pennsylvania*, by J. Gallaher, 1973, 71 p., 12 figs., 9 tables, 1 pl.

W 36 *Summary ground-water resources of Butler County, Pennsylvania*, by C. W. Poth, 1973, 49 p., 4 figs., 7 tables, 1 pl.

W 37 *Summary ground-water resources of Westmoreland County, Pennsylvania*, by T. G. Newport, 1973, 49 p., 9 figs., 6 tables, 1 pl.

W 38 *Summary ground-water resources of Washington County, Pennsylvania*, by T. G. Newport, 1973, 32 p., 5 figs., 6 tables, 1 pl.

W 39 *Summary ground-water resources of Beaver County, Pennsylvania*, by C. W. Poth, 1973, 39 p., 4 figs., 7 tables, 1 pl.

W 40 *Summary ground-water resources of Luzerne County, Pennsylvania*, by T. G. Newport, in press.

NEED FOR FURTHER STUDIES

Ground-water investigations are needed in Pennsylvania to provide a basis for dealing with problems that have already arisen, and to provide a design for the future orderly utilization and management of the ground-water resources of the Commonwealth. It should not be concluded that any investigative program, however detailed, would provide a solution for all current and future problems of ground-water supply. With adequate data many problems can be mitigated or averted, and others can be anticipated and dealt with by appropriate plans and preparations.

Pennsylvania has the ground-water resources to supply its growth needs in the foreseeable future. Local advance planning is needed, however, if we are to avoid water shortages, control pollution, and efficiently develop our ground water in conjunction with our other water resources. To provide the information needed for local planning requires a statewide continuing program of intensive ground-water investigations.

Quantitative information is needed in Pennsylvania. How deep does ground water normally occur in various types of rocks? How much water can be anticipated from a properly located and constructed well? How far apart should wells be drilled for maximum efficiency? Pump tests, in which a well is pumped while careful measurements are taken on

water levels in surrounding wells, can supply much of this information. Electric and radioactive logs will be used to determine the nature of the concealed strata. These logs show the electrical and radioactive properties of rocks. For example, shale has different electrical properties from sandstone, and different patterns are obtained in logging the two types of rock. Therefore, much information can be gained which is of vital importance to the geologic and hydrologic interpretation of an area. The measurement of flow in boreholes, made by using well packers and borehole flow meters, yields information necessary for interpreting well performance and subsurface flow patterns.

The availability of ground water to supply present and future needs is determined first by the occurrence and character of the freshwater-bearing beds, and secondly by the extent to which the natural conditions have been impaired by the actions of man. The natural conditions are very complex. Pennsylvania is underlain by a wide variety of rock formations ranging from crystalline rocks of Precambrian age to unconsolidated deposits of Cretaceous and Quaternary ages. The rocks differ greatly in their thickness and areal extent, composition, texture, geologic structure, and topographic expression; all of these factors influence their capacity to store and transmit water. Furthermore, these same factors show great variations within individual formations, so the regional problems of locating and identifying water-bearing beds are commonly no more complex than the local problems. These factors divide the state into four ground-water provinces, within each of which the ground-water conditions are essentially similar (Figure 5).

In the Piedmont and the Valley and Ridge areas the rocks have been altered in texture, or folded and faulted to expose the beveled edge of the strata at land surface, so the character of the rocks is seldom uniform throughout any large area. The similarity between these regions ends with structure, because radically different rock types and topography are present in each.

In the Plateau areas of western and northeastern Pennsylvania, the rocks are generally flat-lying and have extensive areas of outcrop, but they are deeply dissected by stream valleys, and the individual beds differ markedly in thickness and lithology, commonly grading from sandstone to shale and back to sandstone within a distance of a few hundred feet.

The Pleistocene valley-fill deposits and the Coastal Plain sediments are even more irregularly deposited and chaotically interbedded, and it is seldom possible to trace the water-bearing sands and gravels from one borehole to another. Thus, throughout Pennsylvania, the natural ground-water conditions vary so markedly from place to place that the availability of water at a given site generally cannot be reliably predicted solely on the basis of yields of nearby wells.

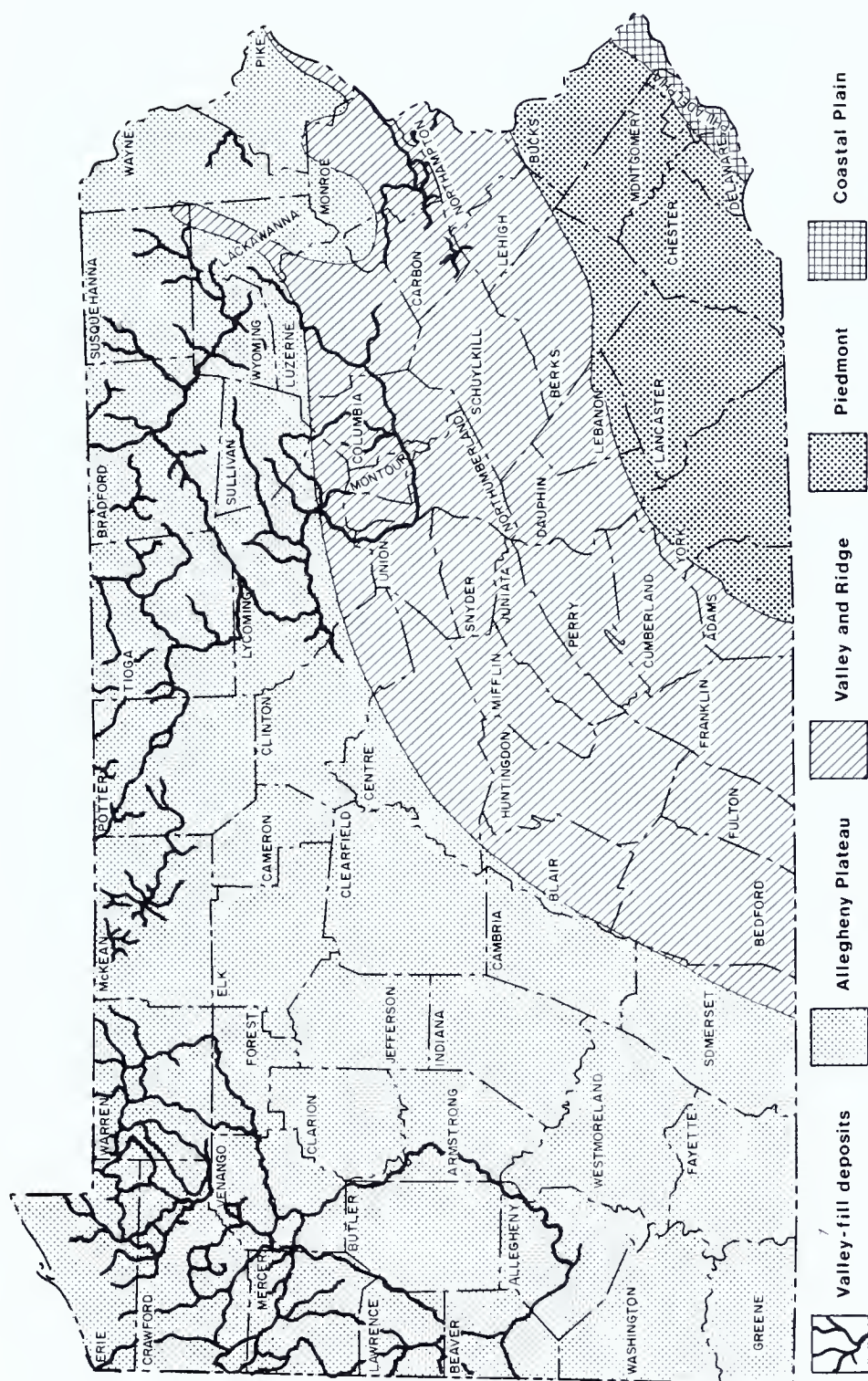


Figure 5. Ground-water province map of Pennsylvania.

The effects of human activities are superimposed upon the natural anomalies of ground-water occurrence. As a result, so-called "problem areas" occasionally develop. Rarely do "problem areas" occur as a direct result of withdrawals of ground water for use; they commonly occur as a consequence of some unrelated activity. For example, in the Triangle area of downtown Pittsburgh, sheet piling was driven to a depth of 40 feet along the bank of the Allegheny River, thereby sealing much of the aquifer from river recharge. In the Philadelphia area the availability of ground water from the unconsolidated deposits poses less of a problem than the quality of water, which has deteriorated largely as a result of pollution of sources of recharge by sewers, disposal wells, and refuse dumps.

Other serious problems of ground-water supply occur in the bituminous coal fields of western Pennsylvania and in the anthracite fields of central and northeastern Pennsylvania. In those areas the most favorable aquifers have been drained or polluted with acid water as a result of the mining activity. Similar problems, but on a more local scale, occur in the limestone valleys of central and southeastern Pennsylvania, except that the pollutants are generally derived from industrial and domestic disposal systems. Water-quality problems also occur locally in the oil and gas fields of north-central and western Pennsylvania, due largely to upward migration of salt water through abandoned boreholes.

The availability of fresh ground water in Pennsylvania is shown on Figure 4. It is apparent that, despite the natural and artificial limitations on the supply, present ground-water use is only a small fraction of the total available resources. It is the joint responsibility of the Commonwealth and its political subdivisions to protect present supplies and to insure the wise conservation and development of the total resources.

PROGRAM FOR CURRENT AND FUTURE GROUND-WATER STUDIES IN PENNA.

The current program consists of four types of investigations:

1. Statewide water-level study.

This is essentially a continuation of the program that was begun in 1930. Under the current program the observation well network will continue to be expanded to provide more comprehensive and representative coverage of the State. The water-level program will be implemented with a mobile force of automatic recorders which will be installed at most sites for a period of time sufficient to define the pattern or trend of the fluctuations, after which the recorders will be removed from some wells and periodic tape measurements will be made.

2. Aquifer studies.

For several years, aquifer studies have been an important part of the ground-water program. They are designed to provide understanding of the hydrologic properties of a specific type of water-bearing formation or lithologic unit.

The aquifer studies are a departure from previous investigative programs in that the primary units of study will have natural hydrologic boundaries rather than artificial political boundaries, as was the case with the County Report series. County reports remain an important part of the program; they will be prepared as they always have been or as by-products of the other phases of the program.

Aquifer units offer definite advantages for orderly and systematic investigation. The field personnel can concentrate on the specific problems related to the aquifer under study; furthermore, they will have more and better opportunities to study both regional characteristics of the aquifer and local anomalous conditions if they can operate over the full extent of the aquifer. However, because of the size of some aquifers and because of lateral changes in lithology in others, studies of some aquifers must be separated into two or more parts, making separate publication necessary.

3. County reports.

County reports will continue to be a major product of the ground-water program in Pennsylvania. The counties studied are selected on the basis of need deriving from actual or expected expansion of domestic or commercial development. An example of this would be our current study of Monroe County and our planned study of Pike County, where expected commercial expansion, due to the proposed Tocks Island Dam and the creation of the Delaware Water Gap National Recreation Area, placed a high priority on obtaining better definition of the ground-water resources of these counties.

4. Special studies.

This category includes research studies and other types of areal investigations such as basin studies. The current program includes one research study of ground-water quality statewide, and a study of the Clarion and Redbank Creek basins.

CURRENT PROJECTS

Today, the ground-water activities of the Pennsylvania Geological Survey are broader than ever before. An expanded program of ground-water services to fellow state agencies, local communities, and the general public is heavily utilized. The data being collected from water well drillers are more effectively analyzed and utilized than ever before. The

cooperative program with the U.S. Geological Survey Water Resources Division is at a peak level; the latter agency operates from Harrisburg, with a staff of 14 working on ground-water projects in various parts of the State (see Figure 3).

The current ground-water program in Pennsylvania includes nine projects, which are listed below. The locations of the projects are shown on Figure 3.

1. Ground-water levels, statewide—the continuing study of trends and patterns of water levels in the State.

2. Ground-water quality in Pennsylvania—a research project in which the chemical character of the water will be related to its environment. Concentrations will be plotted and contoured.

3. Geology and hydrology of northern Berks County—a study of the yielding characteristics of the carbonate rocks and shale in the Great Valley near Reading, Pennsylvania. Geology being mapped by the Pennsylvania Geological Survey.

4. Geology and ground-water resources of Monroe County—geologic mapping being done by Pennsylvania Geological Survey. This study is an appraisal of bedrock aquifers and glacial deposits in an area of expected expansion and commercial development. Much effort is being expended to determine interaquifer flow for definition of subsurface ground-water movement.

5. Geology and ground-water hydrology of the Williamsport area—geologic mapping being done by the Pennsylvania Geological Survey. This study is an appraisal of the availability of ground water in bedrock and in glacial sand and gravel.

6. Geology and ground-water hydrology in the northern part of the Cumberland Valley, Cumberland County—geologic mapping being done by the Pennsylvania Geological Survey in an area of carbonate rocks and shale, to define the yield of the geologic units and to evaluate the effects of urbanization on water quality.

7. Geology and hydrology of western Crawford County—this study is designed to define the availability and quality of water in the bedrock and the overlying glacial deposits. Efforts are being made to determine the depth to salt water.

8. Water resources of the Clarion River and Redbank Creek basins in western Pennsylvania—water in this area has been affected strongly by coal mining. The project is designed to determine the water-bearing properties of the bedrock in the area and to attempt to determine the extent and nature of pollution of both ground and surface waters. Some information on the low flows of streams will also be obtained.

9. Hydrology and geology of Erie County—availability and quality of ground water in glacial deposits and bedrock will be determined. Research on the occurrence of saline water will be a secondary objective.

FUTURE PROJECTS

For the future, a growing demand for water, as well as a growing concern over the pollution of surface water, will result in increasing use and need for ground-water resources in Pennsylvania. In recognition of this trend, the Pennsylvania Geological Survey and the United States Geological Survey have planned for increasing detailed inventories of the ground-water resources of Pennsylvania and increasing services to the water users of the Commonwealth.

According to present plans and needs, the probable order of priority for studies in the next few years is as follows:

1. Ground-water resources of the Cambro-Ordovician limestones and the Martinsburg Formation in the Great Valley in Franklin County.
2. Ground-water resources of the Gettysburg Formation in southeastern Pennsylvania.
3. Ground-water resources of the Devonian and Mississippian rocks in central Columbia County.
4. Ground-water resources of the Devonian rocks and glacial deposits of Pike County.
5. Ground-water resources of the Pennsylvanian rocks in Butler County.
6. Ground-water resources of the Pennsylvanian and Mississippian rocks in Venango County.
7. Ground-water resources of the Paleozoic rocks and glacial deposits of Wayne County.

The progress and success of this program depends on a number of factors but chiefly on the availability of funds and personnel. In addition, it should be recognized that the order of priority for future studies and even the areas selected for study may change to meet unanticipated needs.

